A Qualitative Study of Clinicians Ways of Using a Decision-Support System

Daniel Karlsson[1], Christer Ekdahl[2], Ove Wigertz[1], Urban Forsum[3]
[1] Department of Medical Informatics, [2] Department of Infectious Diseases, and
[3] Department of Clinical Microbiology, Linköping University, Sweden

We have studied how clinicians approached a decision-support system to manage patient cases. The design of the system under study was based on an integration of hypertext and rule-based systems. World-Wide Web technology was used for the implementation of the system.

By using grounded theory and stimulated recall, we found that getting patient-specific support and continuing medical education were the two major usages of the system and that the three parameters relevance, validity, and work were important in describing how the system was experienced by the users.

INTRODUCTION

To aid clinical decision making in the context of documented information needs[1] and reduced funding in the health-care sector, together with recent developments in information technology, we have developed a design for a computerized decision-support system[2] that aims at meeting the demands raised by this new situation. The rationale of the design has been to facilitate the dissemination and use of information to help answer questions and solve problems pertaining to a specific subspecialty. Such problems are known to occur frequently in clinical practice.[3] Furthermore, the design aims at being a platform for just-in-time continuing medical education (CME). The design was implemented using World-Wide Web (WWW) technology to make the system easily accessible.

To guide further developments of our design, a qualitative evaluation of a prototype implementation of the system was performed. The aim of the study was not to validate the system and its knowledge base, but to study the way clinicians use this new way of accessing information.

BACKGROUND

Usefulness of Medical Information

In our work, we adopted the definition of usefulness of information stated by Slawson et al.[4]:

$$\text{usefulness of information} = \frac{\text{relevance} \times \text{validity}}{\text{work}},$$

where relevance was defined as relevance to everyday practice and the type of evidence presented, validity was defined as the probability of the information being correct, and work was defined as the effort needed to obtain the information. Finding information with high validity and high relevance may need a substantial amount of work. Information which is easy to get may not always be relevant or valid. The most useful information is information which is relevant, valid, and easy to get.

Different kinds of information sources have different usefulness profiles.[5] Textbooks are usually easy to get right from the shelf, while they may have low validity since they often are dated. Journal articles may have high validity but low relevance. The contents of the articles are often hard to apply in clinical practice. Expert consultants can be contacted relatively easy, but the validity of the information may vary.

System Design

The system design is based on the concept of integration of hypertext and rule-based decision support. The hypertext knowledge base consists of a set of validated hypertext pages interlinked using the hypertext linking capabilities. The hypertext knowledge base is organized as a traditional text book, divided into parts and chapters, etc. The hypertext can be used as such, i.e. as a text source, or it can be used, through the integration, to get validated explanations and background knowledge for advice produced by the rule-based component.

The rule-based knowledge base consists of a set medical logic modules. Every logic module consists of, among other things, a set of conditions and a message to be displayed whenever the conditions are satisfied. The rule-based component can be used to interpret patient findings and to get patient-specific advice concerning management of a specific patient case. The rule base can also, through the integration, be used to search the hypertext knowledge base for validated information relevant to a specific patient.

1091—8280/97/$5.00

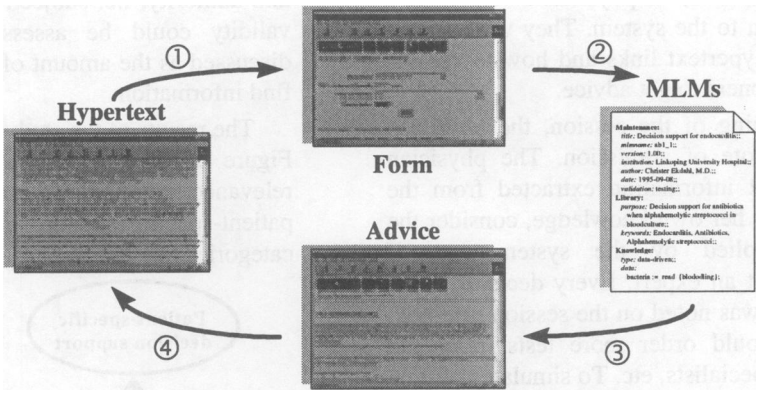

Figure 1. Integration of Hypertext and Rules

When in use, the integration works as follows (see Figure 1). A user may navigate from a hypertext page to a form ①. The form is used to provide the system with patient information. When information has been entered, one or several questions is selected. Then ②, the rule-based component is executed and advice relevant to the patient information provided and the questions asked is given ③. From the advice, it is possible to navigate back into the hypertext knowledge base ④ to get background information or to get more extensive knowledge.

Implementation

The system was implemented as a prototype using WWW technology. The rule-based component was implemented as a part of the HELIOS project[6] and was connected to the WWW server by using the Common Gateway Interface (CGI).

The hypertext pages were implemented as HTML files and the rule-based knowledge base was implemented using Arden Syntax for Medical Logic Modules.[7] The domain used for the prototype was management advice and expert knowledge in bacterial endocarditis.

Choice of Method

The motive for choosing a qualitative, theory generating method for this study was that the system at that moment was in an early development phase. We wanted to know the pros and the cons of using the system and we were not so much interested in how good or bad the system was to use. We wanted to know the system's qualities. In this early stage, it was also impossible to find a reasonable set of usability variables needed for a quantitative study. Therefore, we chose a qualitative method over a quantitative method.

Traditional studies of decision-support system often concern the objective validity of the knowledge base, i.e. according to some gold standard. In our study, we focused our attention on the subjective validity of the system.

METHOD

The study was based on the grounded theory approach[8] for development of a theory of clinicians usage of our decision-support system. We used qualitative data collected from interviews using stimulated recall.[9]

The study was performed in the summer of 1996 with six physicians working at the internal medicine department at Motala Hospital, a 252-bed hospital. Three of the physicians were attending physicians in internal medicine, the other three were residents under training to be specialists. The physicians had only little experience in treating patients with bacterial endocarditis. All of them were reasonably familiar with computers.

The physicians were given responsibility for the management of patient cases given to them on paper. Furthermore, they were told that we would like them to, if possible, use the system to answer questions that may arise during the management of the patient case. Whenever they felt the system could not give enough support, they had the possibility of consulting an expert.

The patient cases were based on authentic cases made unidentifiable. About half of the cases were patients with confirmed bacterial endocarditis and the other half were unspecified or of differential diagnoses to endocarditis, such as Gram-positive septicemia. The cases with differential diagnoses allowed us to study how the system was used when information in the periphery or outside of the system's knowledge base was needed. The cases were chosen by selecting each case from a certain date onwards until a sufficient number of cases had been collected. The cases were given to the physicians at random.

Before each session, the physicians were given a short introduction to the system. They were shown how to use the hypertext links and how to use the rule-based component to get advice.

In the beginning of the session, the physician was given the note of admission. The physician could use patient information extracted from the case, apply his or her own knowledge, consider the information supplied by the system and, if necessary, consult an expert. Every decision made by the physician was noted on the session protocol. The physician could order more tests, refer the patient to other specialists, etc. To simulate the time factor, information was handed out a "case day" at a time.

The physicians' sessions with the system were videotaped. By using a VGA-to-S-VHS interface and a video camera mixed together in a video mixer, both the computer screen and the user were captured at the same time, with the user in a small window in the top right corner.

About a week after the session, the physicians were interviewed. Each physician and the interviewer looked at the videotape together and the physician was asked questions about how he used the system and why. The physician was also told to comment on anything concerning the use of the system. After this the physician was given some general questions. The interviews was recorded on audio tape.

The interviews were transcribed and analyzed according to the constant comparative method.[9] The interviews were examined and, together with the video tapes, were used to identify codes for the physicians usage of the system. The codes were sorted into categories. Based on the categories, a theory of the usage of our system was built. The quotes presented here were translated from Swedish into English for the purpose of this article.

RESULTS

By using the method from above, we found that the two main usages of the system were to get patient-specific decision support and to get CME. A condition that must be fulfilled for the system to be able to meet these demands is that the information supplied by the system is useful. We found that the physicians wanted the system to give them information that was relevant, valid and easy to get, but with slightly different definitions than of Slawson et al.[5] Relevance was discussed from two perspectives: (1) the relevance to the current patient case, and (2) the relevance in everyday clinical practice. Validity was discussed in terms of trust and authority, i.e. subjective validity, and how the validity could be assessed. Work was mostly discussed as the amount of time that was needed to find information.

The results of the study can be summarized as in Figure 2. The impact of the three parameters relevance, validity, and work on the ability to get patient-specific support and CME were the main categories found.

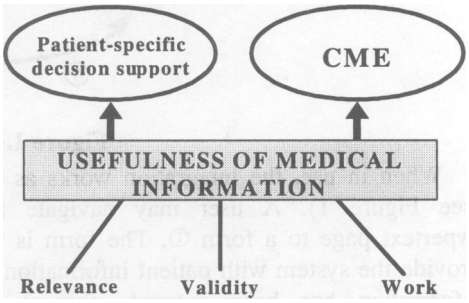

Figure 2. Aspects of Usefulness of the System

Patient-Specific Decision Support

The ability to get patient-specific support was often used by the physicians and, especially while managing patient cases with confirmed endocarditis, also highly appreciated.

Relevance. When the physicians needed information in the periphery or outside of the systems knowledge base, problems often occurred. For example, in the initial phase, when only little patient data was present and no diagnosis was established, the physicians found the system hard to use. There were too many possibilities.

Since bacterial endocarditis is a rare disease, the physicians believed that a system concerning just this disease would not be used. The knowledge base has to be expanded to cover larger areas.

> *"The more information stored in the system, the more I would use it."*

The physicians often discussed the relevance of the information presented in respect to their own knowledge and experience. They said they could use the system to confirm their own decisions and to find support for them in the more extensive knowledge provided by the system.

It was sometimes found hard to extract the relevant details from the text presented by the system. Focusing on relevant details was found easier in a verbal contact with an expert. The physicians also stressed that an expert can give psychological support in a way which a computer system can not.

> *"Certain questions have to be put to a human being."*

"...when you have a seriously ill patient, you want to talk to someone. This means a lot then."

The physicians found the use of forms both as a hindrance and as a way of getting support in what to look for. Problems arose while managing cases in the periphery when the selections in the form were not sufficient.

Validity. In assessing the validity of the rule-based component, the behavior of the physicians could be divided into two separate groups: (1) trusting authority, and (2) wanting to understand the mechanism. Most physicians showed both kinds of behavior.

One physician said that he trusted the advice presented and he compared the situation to consulting an expert. The person responsible for the information presented by the system could be *"the same person I talk to when I call for advice."*

The physicians also got support from the explanations given by the system, i.e. the hypertext pages linked to from the advice.

"(I trusted the system, ed. note) *because there was a motivation for the advice."*

The physicians often wanted to know exactly how the interpretation of patient data had led to the advice presented. This was important for assessment of the validity of the advice.

"(Interviewer) *You said that you had difficulties in trusting the advice?"*

"I didn't know how the data I typed into the system was interpreted. It felt like I didn't know what led to it (the advice, ed. note)*."*

When the system did not react as the physician expected it to, they thought *"What does the computer know that I don't"* or *"Have I typed everything correct?"*. The physicians generally thought that when entering patient data into the forms, it was hard to know whether all data had been correctly entered.

Often the physicians said that, to be really certain, they would have to call an expert to double-check the advice given by the system.

Another important issue for the validity, stressed by most of the physicians, was that the knowledge base was updateable and that it actually was updated.

Work. One aspect was that using the system may be less time consuming than trying to contact an expert, at least when you know how to use the system. When the physicians were not used to the system, contacting an expert was preferred. The complexity of the question also had importance in the choice of using the system or calling an expert. The physicians who worked on two cases naturally found the system easier to use the second time.

By using the system to solve the less complex problems, consulting an expert could be postponed until complex problems arose.

"It (the system, ed. note) *can be time saving. You don't have to make the unnecessary phone consultations and you can wait until you have really important problems to discuss and you don't need to discuss the less complex questions."*

The physicians also wanted to be able to search for information using free-text or index search.

Continuing Medical Education

The possibility of getting CME by using the system was seen as a useful contribution of the system, although some thought that the system seemed to be more geared towards solving clinical problems than towards education.

Relevance. Since learning takes place in the context of real patient cases, the physicians felt that this system could be an effective aid in getting CME.

"I think this is an excellent educational tool, to work with cases. This will be remembered in a different way."

They also stated that there was a need for education and support in the area of endocarditis and other rare diseases.

"We ... who don't work with this (regularly, ed. note) *are left with what we once learned."*

Validity. The time spent using the system was thought of as being under less pressure than the time spent consulting an expert. The expert is an expensive resource and there is little time for getting background and/or more extensive knowledge in contact with the expert. It becomes hard to assess the validity of the advice, especially for inexperienced physicians.

"When you call Linköping (the referral hospital for Motala, ed. note) *you get an answer like 'Do like this, do like that, etc.'. There is no time to ask why the expert gives this advice. If I ask, maybe the expert feels I question his advice. There is no time for learning. You just become a messenger."*

Work. The physicians found that CME could come as a side effect of working with the system. They could pick up information valuable for clinical practice without considerable effort.

DISCUSSION

The generality of the results of the study is, due to its qualitative nature, hard to define. The focus on the study was to evaluate the usage of our system implementation in order to direct further developments. Future quantitative studies may add generality to our results.

The physicians had only limited time to use the system and the introduction to the system given in the beginning of the session was obviously insufficient. This unfamiliarity with the system was probably the main cause of some of the problems experienced by the physicians. We tried to go behind this in the interviews and the analysis.

One of the goals of our design was to provide extended explanations to given advice, i.e. to provide a set of links to hypertext pages related to the advice. This was a possibility actually used by the physicians. As the physicians pointed out though, the system must be more explicit in the way it explains why a certain piece of advice has been given. This could perhaps be implemented by adding more detailed explanations to the messages. Caution must, however, be taken not to make the messages too verbose.

The physicians also addressed a possibility of searching the knowledge base using index words in extension to the hypertext links. This, we think, can be provided by using the system in conjunction with a controlled medical terminology as described in Karlsson et al.[10]

To summarize, it seems like we have developed a design that has a potential of providing information with a satisfying usefulness profile. The use of the rule-based component can improve the relevance and also reduce the work needed to find hypertext-based information. The validity of the system may be controlled since it is mainly based on the validity of the documents provided. Each suggestion made by the system can be checked in hypertext documents. Validity may also be controlled since the knowledge base is updateable, although keeping the system up-to-date may require a large amount of work from the system maintainers.

To continue this work we are planning to adjust our system design according to the lessons learned from this work. The new design will be implemented as a prototype and will concern urinary tract infections, a much more common disease. We plan to study this system as it is used in the general practitioner's office.

Acknowledgments

This work was supported by NUTEK, the Swedish National Board for Industrial and Technical Development (Project no. 94-4876P).

References

1. Smith R. What clinical information do doctors need? BMJ 1996;313:1062-8.
2. Karlsson D, Ekdahl C, Wigertz O, Shahsavar N, Gill H, Forsum U. Extended telemedical consultation using Arden Syntax-based decision support, hypertext, and WWW technique. In press. Meth Inform Med 1997; 36.
3. Covell DG, Uman GC, Manning PR. Information needs in office practice: Are they being met? Ann Intern Med 1985;103:596-9.
4. Slawson DC, Shaugnessy AF, Bennet JH. Becoming an information master: feeling good about *not* knowing everything. J Fam Pract 1994;38:501-13.
5. Shaugnessy AF, Slawson DC, Bennet JH. Becoming an information master: a guidebook to the medical information jungle. J Fam Pract 1994;39:489-99.
6. Åhlfeldt H, Shahsavar N, Gao X, Arkad K, Johansson B, Wigertz O. Data driven medical decision support based on Arden Syntax within the HELIOS environment. Comp Meth Prog Biomed 1994;45:S97-S106.
7. Hripcsak G, editor. Special Issue: The Arden Syntax. Comp Biol Med 1995;5.
8. Strauss A, Corbin J. Basics of Qualitative Research: Grounded Theory Procedures and Techniques. Newbury Park: SAGE Publishing; 1990.
9. Arborelius E, Timpka T. In what way may videotapes be used to get significant information about the patient-physician relationship? Med Teacher 1990;12:197-208.
10. Karlsson D, Carlsson M, Forsum U, Wigertz O. A design for a World Wide Web decision-support system using a controlled medical terminology, In: Cimino JJ, editor. Proceedings of the 1996 AMIA Annual Fall Symposium. Philadelphia: Hanley & Belfus; 1996. p. 189-93.